N90-16645

THERMAL HISTORIES OF THE SAMPLES OF TWO KOSI COMET NUCLEUS SIMULATION EXPERIMENTS; T. Spohn[1] , J. Benkhoff[1] , J. Klinger[2,4] , E. Grün[3] , and H. Kochan[2]; 1) Institut für Planetologie, Westfälische Wilhelms-Universität, 4400 Münster 2) Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt e.V., 5000 Köln 90 3) Max Planck Institut für Kernphysik, 6900 Heidelberg 4) Laboratoire de Glaciologie et de Geophysique de l' Environnement, St. Martin d' Hères (France)

Temperatures recorded during two KOSI comet nucleus simulation experiments strongly suggest that heat transport by vapor flow into the interior of the sample is very important.

Two comet nucleus simulation experiments have been done by the KOSI team in a big space simulator at the Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt (DFVLR) in Köln/Porz. Detailed reports on the experiments have been given by Grün *et al.*(1) and by Kochan *et al.*(2,3) Here, we will report on the thermal evolution of the sample during insolation and we will discuss the results of simplified thermal evolution calculations.

The space simulator used at DFVLR/Köln is basically a vacuumized cylinder of $4.8m$ length and $2.4m$ diameter. The interior is cooled by liquid nitrogen and the interior pressure is kept constant at $10^{-4} Pa$. The two samples were $30cm$ in diameter and 12 and $15cm$, respectively, in thickness. The first experiment, henceforth referred to as KOSI-1, was done in the spring of 1987 and the second, KOSI-2, was done in the spring of 1988. The dust to water ratio was 1/10 for both experiments and the dust component was a mixture of clay minerals, with 0.083% by weight carbon added for KOSI-2. The admixture of carbon resulted in an albedo of 0.06. The samples consisted of frozen droplets of mostly submillimeter size; the density was about $600kg/m^3$ and the porosity was estimated to be 0.4. The samples were insolated by Xenon lamps for 2 hours at $714W/m^2$ followed by 10 hours at $1000W/m^2$ during KOSI-1 and for 16.5 hours at $1360W/m^2$ during KOSI-2. During both experiments, the bottom of the sample was cooled by liquid nitrogen to enforce a constant temperature of about $100K$. Following the period of insolation at a constant rate during KOSI-2, there was a second period of insolation at a varying rate which, however, is not of interest for the present purpose. A layer of about $3cm$ thickness sublimated during KOSI-1 while mass spectrometry suggested a total mass loss of about $400g$ during KOSI-2. Near surface layers of $5cm$ and $4cm$ thickness of metamorphosed or annealed ice were observed while the samples were analized after the experiments. The texture of the metamorphosed ice differed considerably from that of the original sample. The metamorphosed ice was mechanically hard but still porous while the original sample was a loose agglomerate of spherules.

The temperature recordings of KOSI-2 are shown as an example in fig. 1. The most striking feature of the temperature profiles is their convex shape attained after 5 to 10 hours into the experiment. The initial temperature profile increased from $100K$ at the backplate to about $140K$ at the surface. After about five hours in both experiments the thermocouple next to the surface was at a temperature of about $200K$, close to the sublimation temperature of $205K$ at the chamber pressure. A close to equilibrium temperature profile was reached after about 9 hours for KOSI-1 and 15 hours for KOSI-2. Following this time, only small increases in temperature were recorded.

The observed thermal histories cannot be explained by a simple model with heat transferred by heat conduction at a constant conductivity. In order to explain the observed thermal histories we considered a coupled heat and mass transfer problem. The porous ice matrix was assumed to have a constant thermal conductivity and to be in thermal equilibrium with vapor in the pores,

the internal pressure beeing the vapor pressure. The vapor was modelled as an ideal gas because, at the temperatures relevant to our problem, the mean free path length of the vapor molecules is large in comparison with the pore dimensions. The heat capacity at constant volume per unit mass of the two phase mixture was also assumed constant. The vapor was allowed to flow and transfer heat in response to an internal pressure gradient.

In fig. 1 we show the results of a simplified model calculation for which we have *a priori* assumed the shape of the vapor velocity profile. We have fitted the calculated temperature profiles to the measured profiles by adjusting a suitably defined Peclet number, a dimensionless insolation parameter, and a Stefan number. We found that about 60% of the insolation rate is transferred into the interior of the sample via the vapor. In addition, we found an apparent thermal diffusivity of the ice matrix of $(2 \pm 1 \times 10^{-8} m^2 s^{-1})$.

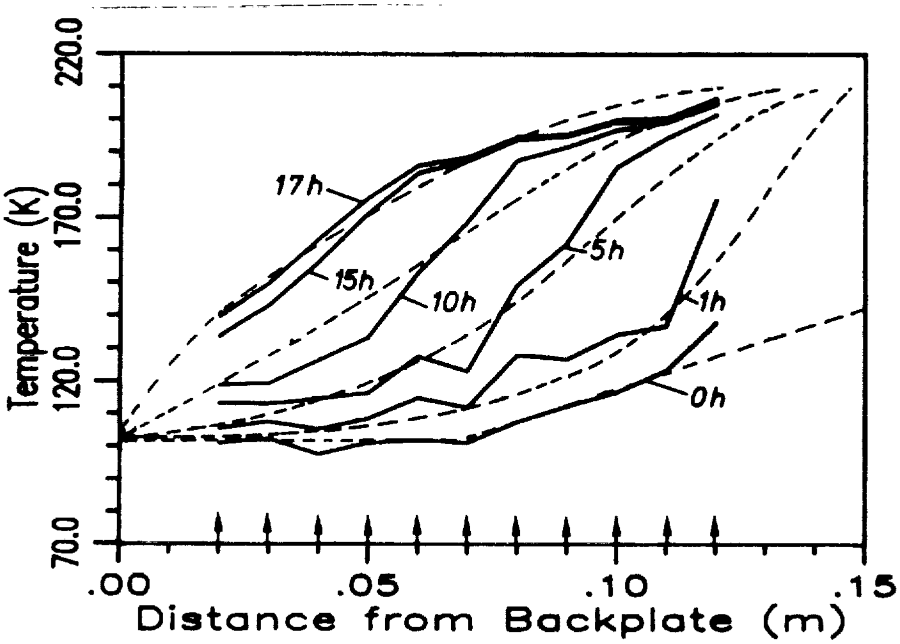

Fig. 1. Temperature profiles recorded during the KOSI-2 experiment (fat lines) and calculated from a simple thermal model (broken lines) at various times after the start of insolation. The location of the thermocouples is indicated by arrows.

REFERENCES

1. E. Grün, H. Kochan, K. Roessler, and D. Stöffler, *ESA-SP/278*, 501-508 (1987)

2. H. Kochan, J. Benkhoff, A. Bischoff, H. Fechtig, B. Feuerbacher, E. Grün, F. Joó, J. Klinger, H. Kohl, D. Krankowsky, K. Roessler, W. Seboldt, K. Thiel, G. Schwehm, and U. Weishaupt, *Proc. 19th Lunar and Planet. Sci. Conf.*, in press (1988)

3. H. Kochan, B. Feuerbacher, F. Joó, J. Klinger, W. Seboldt, A. Bischoff, H. Düren, D. Stöffler, T. Spohn, H. Fechtig, E. Grün, H. Kohl, D. Krankowsky, K. Roessler, K. Thiel, G. Schwehm, and U. Weishaupt, *Adv. Space Res.*, in press (1988)